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BEKASI-EAST JAKARTA AIRPORT
AIR SIDE

Attachment

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1.1 Meteorology

1.1.1 Temperature

In order to calculate the temperature of reference, the ICAO definition has been followed. Thus, an archive which could give the maximum temperature of each day of one entire month during a range of 4 or more years have been search. After an scrupulous research through the Internet, a database successfully meet our requirements. An Excel worksheet has been made in order to gather all the maximum temperatures and calculate the medium maximum temperature of each year.

After that, the medium maximum temperature between 2014 and 2017 have been calculated by adding each year maximum medium temperature and dividing it by 4. The final temperature of reference (T_{ref}) obtained by this method is 32,38°C.

2 | Runway design

2.1 Declared distances

2.1.1 Runway 1

The first declared distance that will be calculated is the landing distance. Using the maximum landing weight (251.000kg) which can be found in the ACAP paper and considering standard atmosphere conditions and sea level, the value can be obtained using the graph shown below:

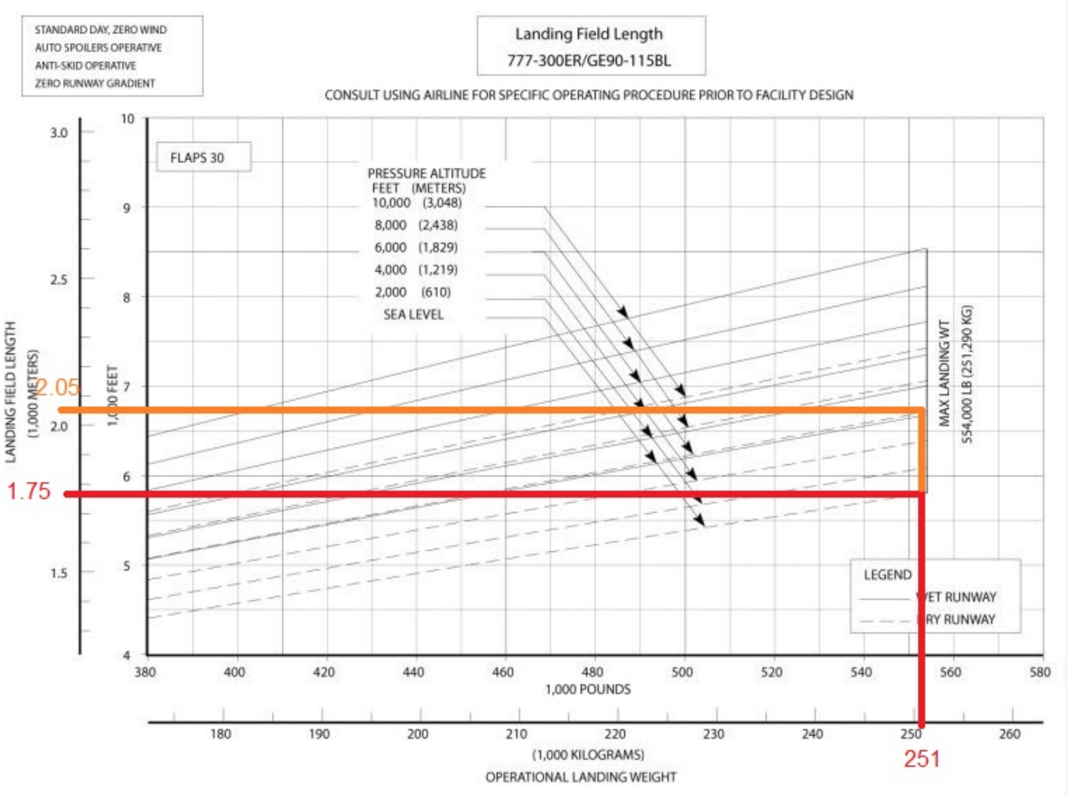

Figure 2.1.1: Landing distance vs MTOW for the Boeing 777.

The landing distance is 1.750m for dry runway and 2.050 for wet runway. Since the runway length is higher than those values, the available landing distance will be equal to the runway length. Now, increasing its value by a coefficient of 67%, the final landing distance obtained is 2.920m in dry runways and 3.417m.

The next distance that will be calculated is the takeoff length without engine failure (TODA). In order to calculate it, the reference field length (3.290m) will be corrected with a factor of 15%. The final TODA obtained is 3.783m.

Moving into the takeoff length with engine failure (TORA), some hypotheses need to be done in order to calculate the final distance. Due to the fact that the engine failure occurs after the critical velocity (v1) which is achieved at the 70% of the runway total length, the thrust coefficient is reduced after that point. The final TORA obtained has a value of 4.120m.

Finally, the last declared distance is the Accelerate-Stop Distance Available (ASDA). This distance also requires a hypothesis in order to be solved. The takeoff is cancelled before the critical velocity (v1), thus at the 65% of the runway length. To compute the final ASDA, the landing distance has to be added to the 65% of the runway length. The value obtained is 3890m.

All the declared distances obtained are minimum values, thus, in order to give them a safety margin due to the amount of hypothesis made during the estimation of the values, all the distances have been further increased.

2.1.2 Runway 2

Moving into the second runway, the first declared distance that will be calculated is the landing distance. The value can be obtained using the graph found on the air plane ACAP data-sheet. The maximum landing weight (66.300kg) which can be found in the same paper and considering standard atmosphere conditions and sea level, the value obtained is 1.750m for dry runway and 2.050 for wet runway.

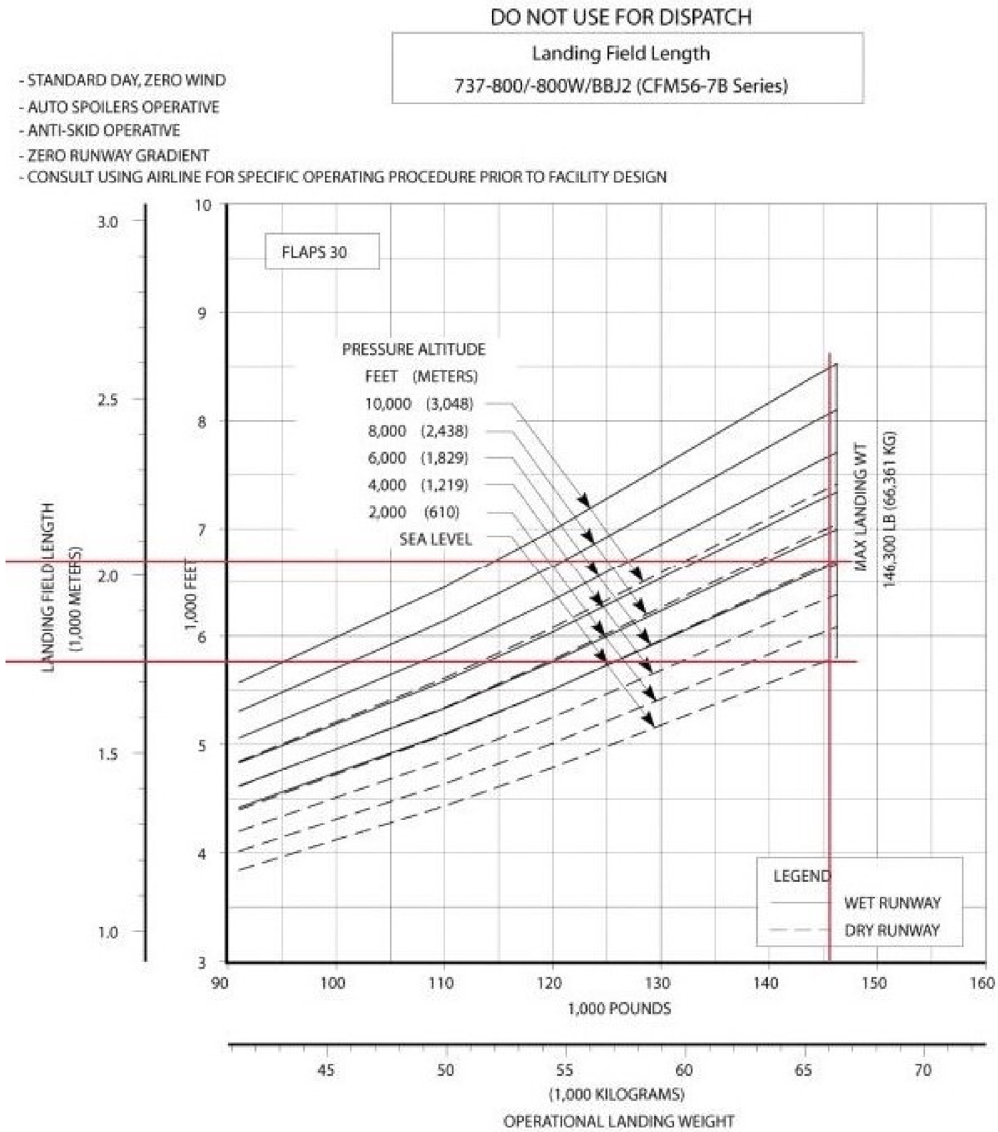

Figure 2.1.2: Landing distance vs MTOW for the Boeing 737.

Applying the 67% safety factor, the values obtained are: 2920m for dry runway and 3423m for wet runway.

The next distance that will be calculated is the takeoff length without engine failure (TORA). The reference field length (2.530m) will be corrected with a factor of 15%. The final TORA obtained is 2.750m.

Moving into the takeoff length with engine failure (TODA), some hypotheses need to be done in order to calculate the final distance. Due to the fact that the engine failure occurs after the critical velocity (v1) which is achieved at the 70% of the runway total length, the thrust coefficient is reduced after that point. The final TODA obtained has a value of 3.160m.

Finally, the last declared distance is the Accelerate-Stop Distance Available (ASDA). As for the 777, this distance requires a hypothesis in order to be solved. The takeoff is cancelled before the critical velocity (v1), thus at the 65% of the runway length. To compute the final ASDA, the landing distance has to be added to the 65% of the runway length. The value obtained is 3.400m.

As for the runway 1, the values obtained here are the minimum required, thus, in order to give it a security margin due to the amount of hypothesis made during the calculations, the final values may be increased.

2.2 Pavement

2.2.1 Runway 1

In order to calculate the pavement of the runway, the parameter needed are the following:

- The number of operations per year of the most critical aircraft.

- The maximum take off weight and landing gear configuration of the critical plane.

- An estimation of the local ground CBR.

Due to the fact that the Boeing 777 has the maximum gross weight by far and its number of operations is close to a 10% of the total operation on the runway 1, it has been chosen as the critical aircraft in order to calculate the runway thickness.

The number of operations can be estimated using the prognosis, the maximum gross weight and landing configuration can be obtained form the aircraft's ACAP and the local ground CBR value is estimated to 5. Thus, introducing the number of operations per year, which are 6.500 Op/year approximately, using a gross weight of 750.000lbs and a CBR of 5 and making use of the following graph obtained from the FAA, the value of the maximum thickness (T_t) can be obtained:

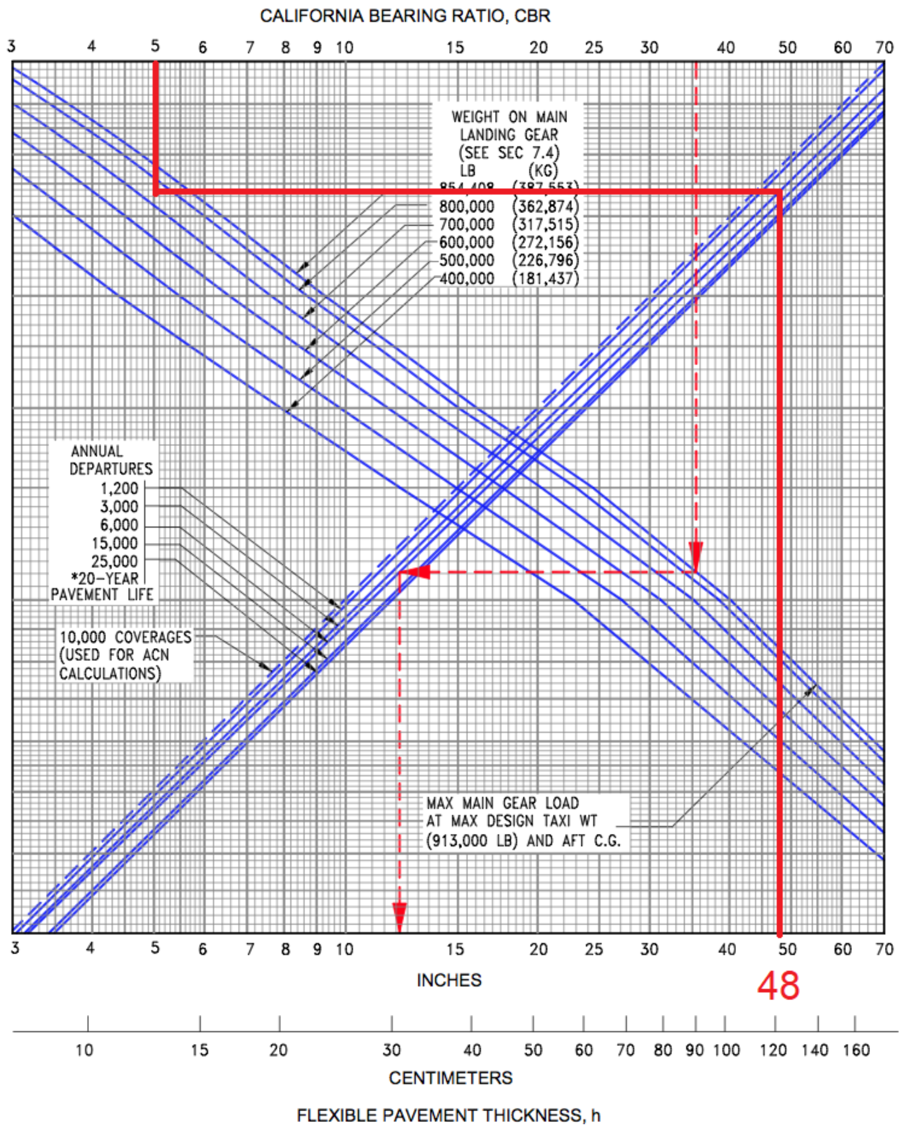

Figure 2.2.1: Thickness vs gross weight, CBR and operations per year.

As it is stated on the figure, the value of thickness obtained is 48in, which are 122cm.

Now, the next step is to calculate the thickness that will have the first two layers. In order to do that, the same graph will be used. However, this time, the CBR of the cement will be considered 25.

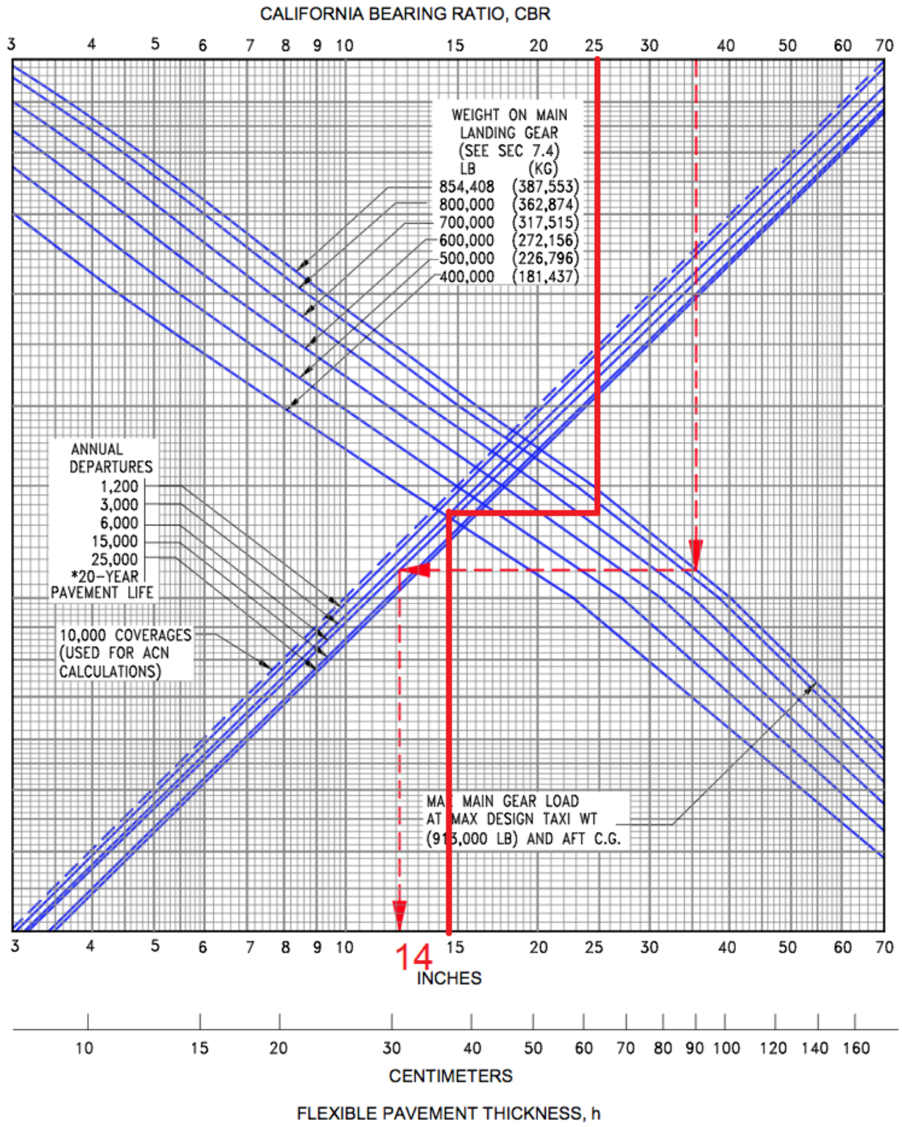

Figure 2.2.2: Thickness of the two first layers vs gross weight, CBR and operations per year.

The value obtained is 14in which are 36cm. Considering a first layer (T_1) of 13cm, the thickness of the second layer (T_2) will be 23cm. Before considering the results as valid, a testing of the minimum thickness of (T_1) and (T_2) has to be done according to the FAA. To do so, the graph shown above must be followed:

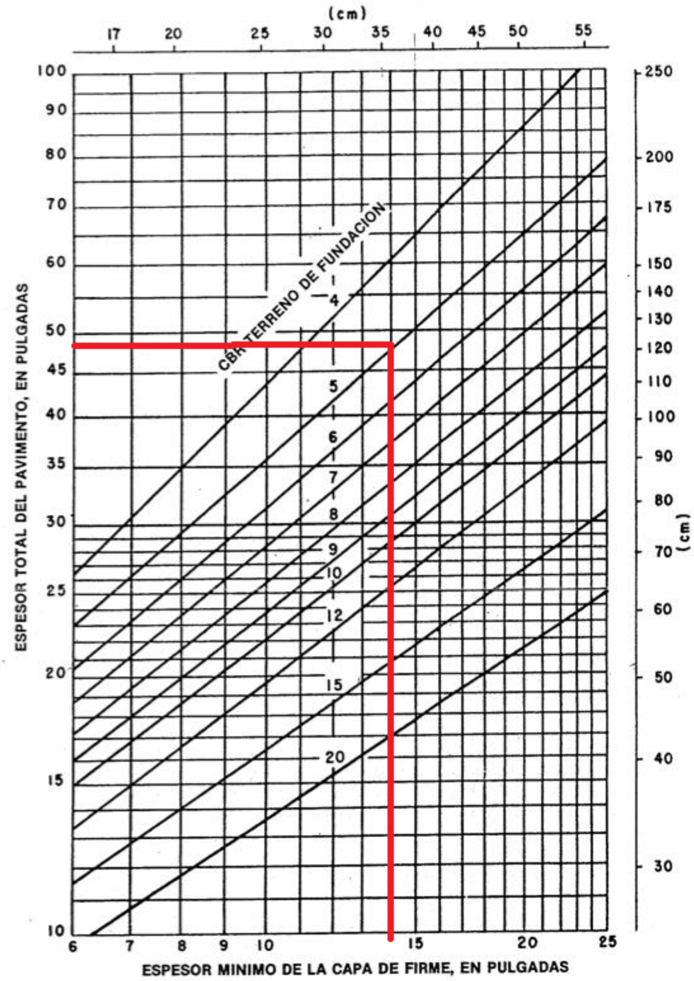

Figure 2.2.3: Minimum thickness of the two first layers vs total thickness.

As it can be seen, entering the maximum thickness and the estimated CBR, the value of 14in for the first two layers is obtained. That exactly the same value that we had calculated using the other graph method, thus, the thickness of the first two layers is correct.

Moving on to the calculation of the last layer (T_3), it can be easily done by once the other 3 thickness are known.

$$T_3 = T_t - T_1 - T_2 = 122 - 23 - 13 = 86cm$$

The final value obtained is 86cm. Now, the next step is to consider each material used on the cement and firms using the following tables extracted form the FAA:

Material	Valores del factor de equivalencia
Capa de rodadura asfáltica	1,7-2,3
Capa de firme asfáltica	1,7-2,3
Capa de firme asfáltica aplicada en frío	1,5-1,7
Capa de firme mezclada en el lugar	1,5-1,7
Capa de firme tratada con cemento	1,6-2,3
Capa de firme de cemento sobre el terreno	1,5-2,0
Capa de firme de árido machacado	1,4-2,0
Capa de cimentación de grava	1,0

Figure 2.2.4: Cement materials and their equivalence factor.

Material	Valores del factor de equivalencia
Capa de rodadura asfáltica	1,2-1,6
Capa de firme asfáltica	1,2-1,6
Capa de firme asfáltica aplicada en frío	1,0-1,2
Capa de firme mezclada en el lugar	1,0-1,2
Capa de firme tratada con cemento	1,2-1,6
Capa de firme de cemento sobre el terreno	No se aplica
Capa de firme de árido machacado	1,0
Capa de cimentación	No se aplica

Figure 2.2.5: Firm materials and their equivalence factor.

The materials and values of equivalence chosen are:

- Firm asphalt with a value of 1,1.

- Crushed arid in cement with a value of 1,4.

The next step is to divide the thickness of the T_2 by 1,1 and the thickness T_3 by 1,4. The minimum values have been chosen in order to maximise the security factor of the runway.

The final values obtained will be displayed on the table below:

T_1	13 cm
T_2	21 cm
T_3	62 cm
T_t	95 cm

Table 2.2.1: Thickness after the materials correction factor.

However, the values obtained form correcting the thickness with the materials is not enough, there is still one more correction to be done, the one regarding the number of operations per year. To do that, the maximum number of operations per year stated on the prognosis will help us to solve the following equation:

$$T_{total} = T_t * (1 + 0,133 * \log(\frac{N}{25.000})) = 95 * (1 + 0,133 * \log(\frac{135.000}{25.000})) = 104,5cm$$

Finally, the total thickness is obtained with a value of 104,5cm. The last step is to distribute the increase of thickness between the three layers. The final thickness of each layer will be the following:

T_1	14 cm
T_2	25 cm
T_3	65,5 cm
T_t	104,5 cm

Table 2.2.2: Final values of thickness of each layer.

2.2.2 Runway 2

As for the runway1, the same parameters are needed in order to calculate the thickness od the second runway. In this case, the critical aircraft is the Boeing 737 due to its high MTOW and its huge number of operations on the domestic runway.

The number of operations can be estimated using the prognosis, the maximum gross weight and landing configuration can be obtained form the aircraft's ACAP and the local ground CBR value is estimated to 5, like in runway 1. Thus, introducing the number of operations per year, which are 20.000 Op/year approximately, using a gross weight of 160.000lbs and a CBR of 5 and making use of the following graph obtained from the FAA, the value of the maximum thickness (T_t) can be obtained:

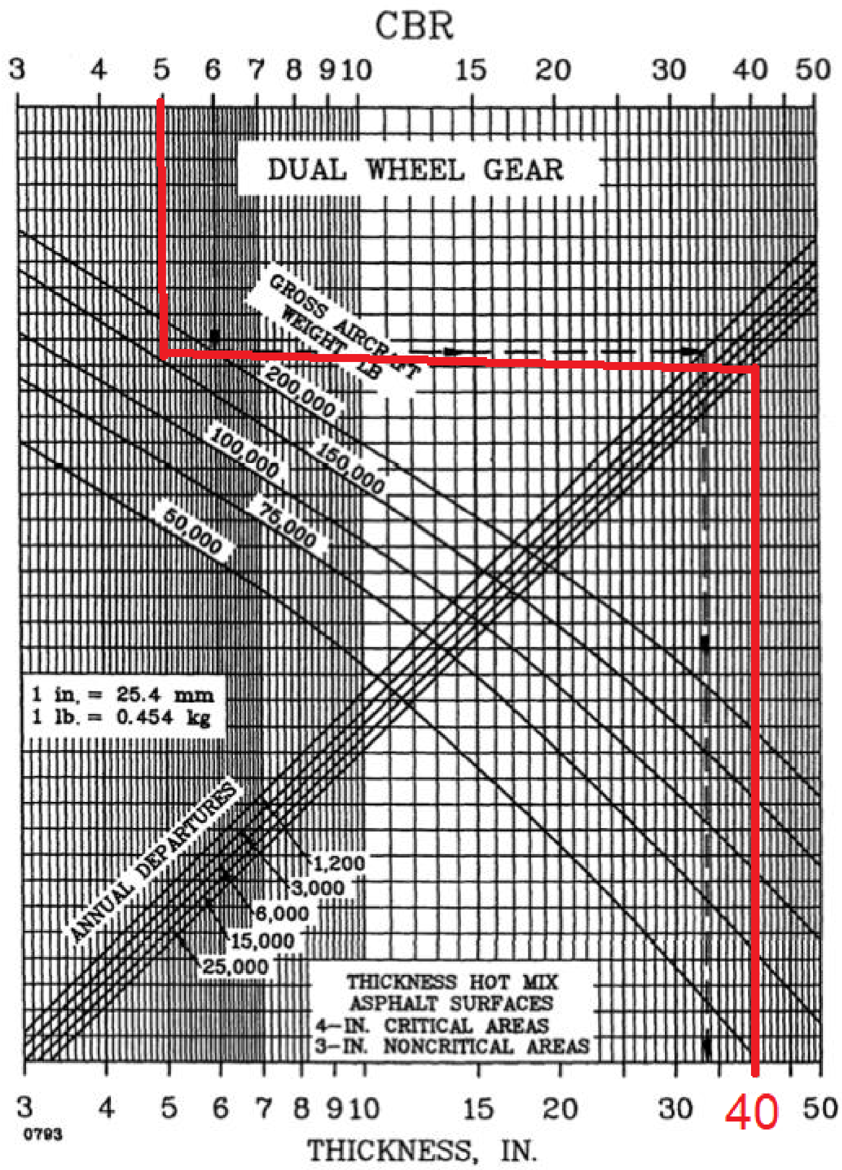

Figure 2.2.6: Thickness vs gross weight, CBR and operations per year.

As it is stated on the figure, the value of thickness obtained is 40in, which are 102cm.

Now, the next step is to calculate the thickness that will have the first two layers. In order to do that, the same graph will be used. However, this time, the CBR of the cement will be considered 25.

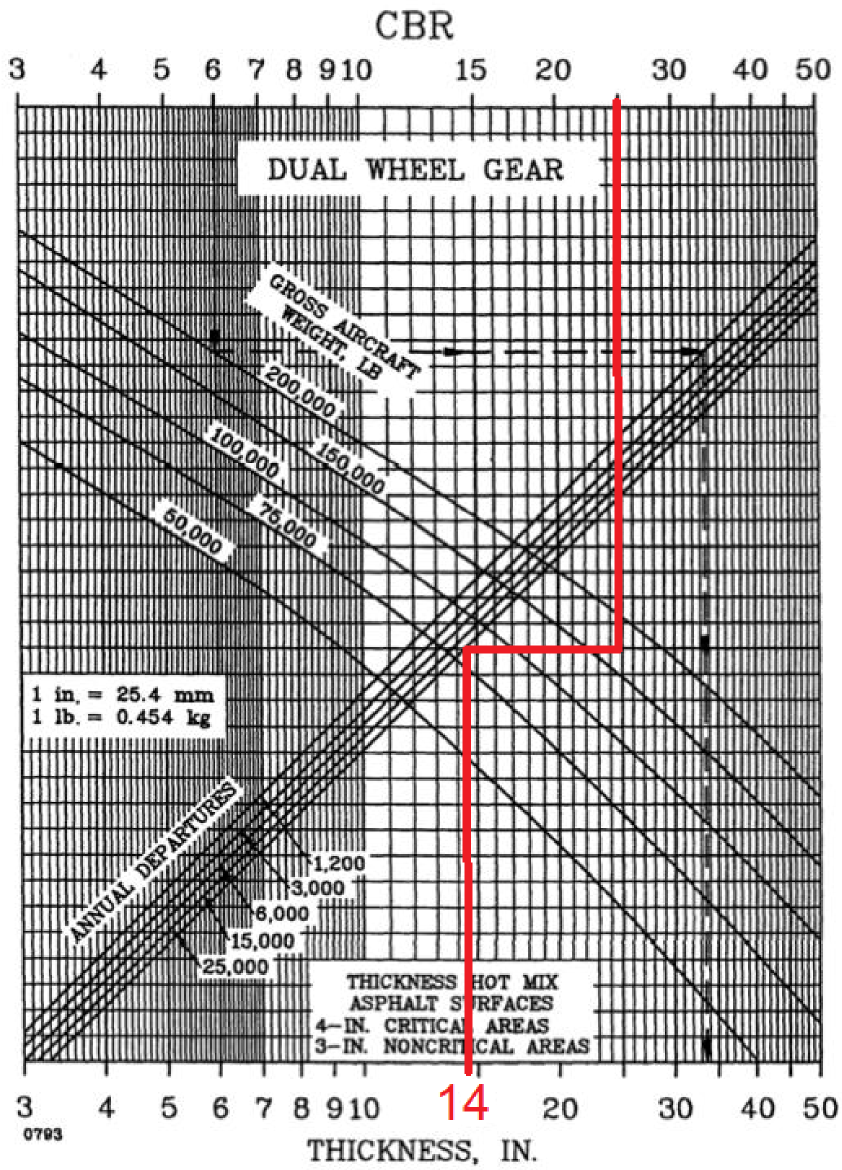

Figure 2.2.7: Thickness of the two first layers vs gross weight, CBR and operations per year.

The value obtained is 14in which are 36cm. Considering a first layer (T_1) of 12cm, the thickness of the second layer (T_2) will be 24cm. Before considering the results as valid, a testing of the minimum thickness of (T_1) and (T_2) has to be done according to the FAA. To do so, the graph shown above must be followed:

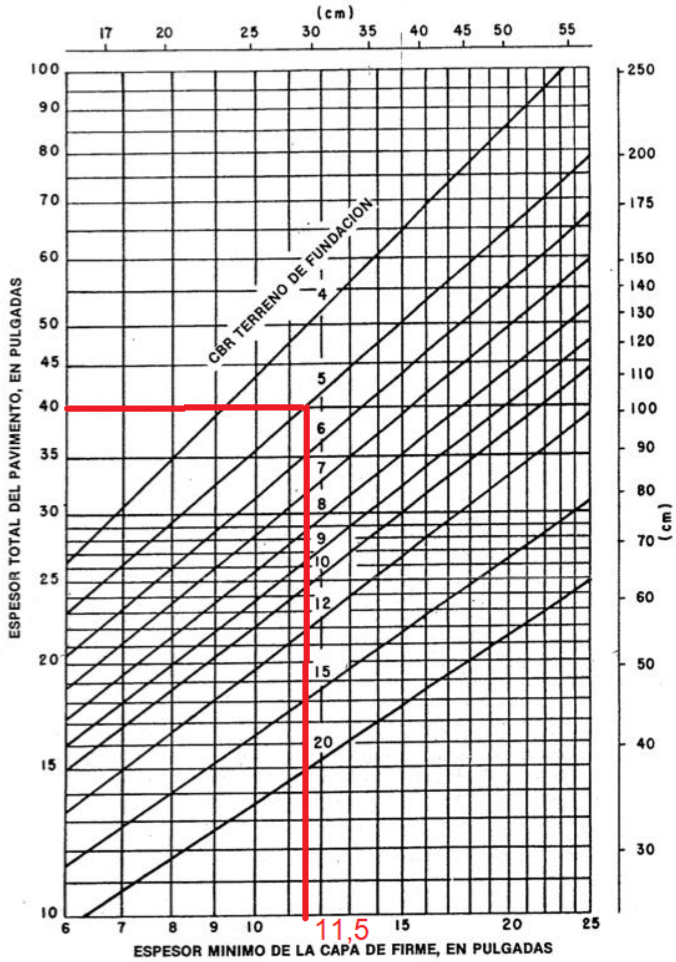

Figure 2.2.8: Minimum thickness of the two first layers vs total thickness.

As it can be seen, entering the maximum thickness and the estimated CBR, the minimum value of 11,5in for the first two layers is obtained. Due to the fact that the thickness obtained by the other method has a value of 14in, the result is considered valid since its value is greater than the minimum required by the FAA.

Moving on to the calculation of the last layer (T_3), it can be easily done by once the other 3 thickness are known.

$$T_3 = T_t - T_1 - T_2 = 102 - 24 - 12 = 66cm$$

The final value obtained is 66cm. Now, the next step is to consider each material used on the cement and firms using the following tables extracted form the FAA:

Material	Valores del factor de equivalencia
Capa de rodadura asfáltica	1,7-2,3
Capa de firme asfáltica	1,7-2,3
Capa de firme asfáltica aplicada en frío	1,5-1,7
Capa de firme mezclada en el lugar	1,5-1,7
Capa de firme tratada con cemento	1,6-2,3
Capa de firme de cemento sobre el terreno	1,5-2,0
Capa de firme de árido machacado	1,4-2,0
Capa de cimentación de grava	1,0

Figure 2.2.9: Cement materials and their equivalence factor.

Material	Valores del factor de equivalencia
Capa de rodadura asfáltica	1,2-1,6
Capa de firme asfáltica	1,2-1,6
Capa de firme asfáltica aplicada en frío	1,0-1,2
Capa de firme mezclada en el lugar	1,0-1,2
Capa de firme tratada con cemento	1,2-1,6
Capa de firme de cemento sobre el terreno	No se aplica
Capa de firme de árido machacado	1,0
Capa de cimentación	No se aplica

Figure 2.2.10: Firm materials and their equivalence factor.

The materials and values of equivalence chosen will be the same as for runway 1 in order to ease the construction of the runway process. Thus:

- Firm asphalt with a value of 1,1.

- Crushed arid in cement with a value of 1,4.

Dividing the thickness of the T_2 by 1,1 and the thickness T_3 by 1,4, the values obtained after the materials correction are:

T_1	12 cm
T_2	21 cm
T_3	47 cm
T_t	81 cm

Table 2.2.3: Thickness after the materials correction factor.

However, the values obtained form correcting the thickness with the materials is not enough, there is still one more correction to be done, the one regarding the number of operations per year. To do that, the maximum number of operations per year stated on the prognosis will help us to solve the following equation:

$$T_{total} = T_t * (1 + 0,133 * \log(\frac{N}{25.000})) = 81 * (1 + 0,133 * \log(\frac{270.000}{25.000})) = 91,5cm$$

Finally, the total thickness is obtained with a value of 91,5cm. The last step is to distribute the increase of thickness between the three layers. The final thickness of each layer will be the following:

T_1	13 cm
T_2	23 cm
T_3	55,5 cm
T_t	91,5 cm

Table 2.2.4: Final values of thickness of each layer.

3 | Taxiway design

3.1 Introduction

3.2 Taxiway width

3.3 Taxiway turns

3.4 Taxiway overwidths (sobreanchos)

3.5 Taxiway shoulders

3.6 Taxiway strips

3.7 Rapid exit taxiways

3.7.1 Introduction

3.7.2 Number of rapid exit taxiways

3.7.3 Design of rapid exit taxiways

4 Holding positions

4.1 Introduction

4.2 Minimum distance between holding position and runway

4.3 Interference with critical and ILS sensible areas

4.4 Interference with CWY and physical obstacles

4.4.1 Separation between aircraft (guardas entre aeronaves)

4.5 Final design of holding positions

5 | Apron design

5.1 Pavement

In order to calculate the thickness of the rigid pavement, the following parameters are needed:

- The flexural resistance of the cement in psi.

- The coefficient of resistance of the cement that is going to be placed in the pavement (K).

- The maximum takeoff weight of the critical aircraft that is going to operate on the apron.

- The number of operations a year of the plane.

The critical aircraft is the B737 due to the large amount of operations every done a year, more than 40% of the total operations in comparison with the less than a % done by de 777. Another possible candidate is the Airbus A320, however, it has been discarded due to the fact that the B737 has a higher MTOW.

Moving into the thickness calculation, using the flexural resistance of 600psi, a parameter K of 180psi, a MTOW of 170.000lbs, a number of operations a year of 25.000 and introducing those inputs in the following graph taken from the FAA:

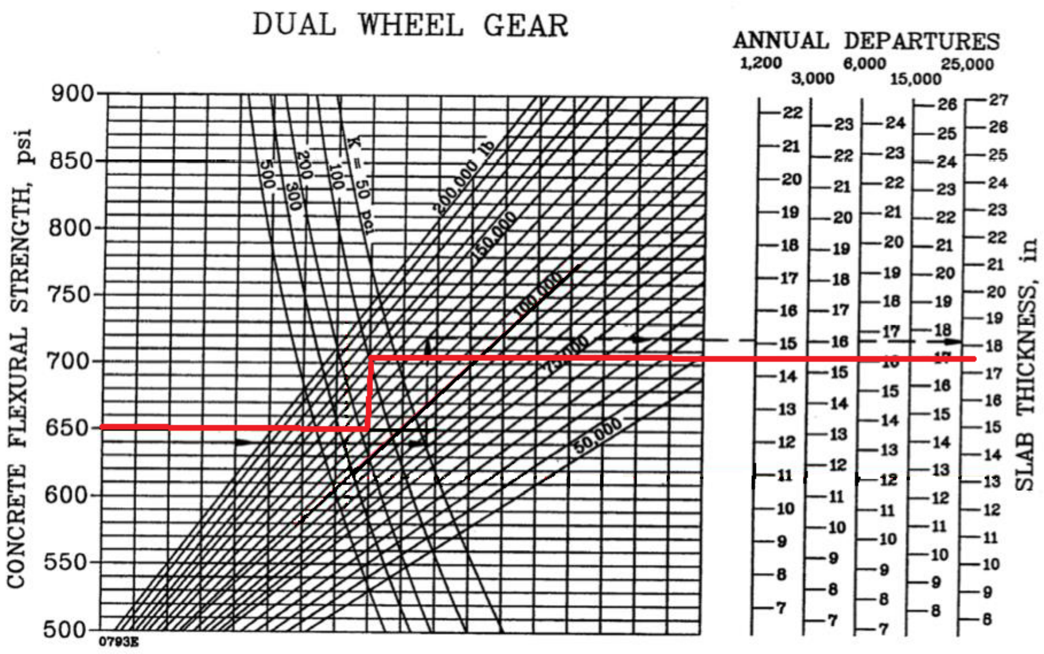

Figure 5.1.1: Thickness of the cement slab.

The value of thickness obtained is 17,5in, which are 44cm. However, this thickness has to be corrected by the total number of operations done in the apron. Using the same equation used in the calculations of the runway's pavement:

$$T_{total} = T_t * (1 + 0,133 * \log(\frac{N}{25.000})) = 44 * (1 + 0,133 * \log(\frac{270.000}{25.000})) = 51cm$$

The final value of the slab's thickness obtained after the correction is $T_{total} = 51cm$.

6 Markings

6.1 Runway markings

6.1.1 Runway centerline markings

6.1.2 Runway side strip markings

6.1.3 Runway threshold markings

6.1.4 Runway Idesignation marking

6.1.5 Runway aiming point markings

6.1.6 Runway touchdown zone markings

6.2 Taxiway markings

6.2.1 Taxiway centerline markings

6.2.2 Taxiway strip markings

6.2.3 Taxiway holding position markings

6.2.4 Intermediate holding position markings

6.2.5 Runway entry holding position markings

6.2.6 Mandatory instruction marking

6.3 Apron markings

6.3.1 Apron lead in line markings

7 Lights

7.1 Runway lights

7.1.1 Approach lights

7.1.2 Approach slope indication systems

7.1.3 Runway threshold identification lights

7.1.4 Runway edge lights

7.1.5 Runway threshold and wing bar lights

7.1.6 Runway end lights

7.1.7 Touchdown zone lights

7.1.8 Runway rapid exit lights

7.2 Taxiway lights

7.2.1 Taxiway lights

7.2.2 Taxiway lights for an exit taxiway

7.2.3 Taxiway light for a rapid exit taxiway

7.2.4 Taxiway edge lights

7.2.5 Stop bar lights

7.2.6 Intermediate holding point lights

8 Signs

8.1 Mandatory instruction signs

8.2 Information signs

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9.1 Electrical system general design

9.2 Connection sub-stations

9.3 Electric powerplant

9.4 Electrical transformation center

9.5 Channeling and distribution of the electrical system

10 Medium voltage electrical system

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10.1.2 Taxiway centerline lighting system

10.1.3 Runway and taxiway centerlines lighting system

10.1.4 Approach lighting system

10.1.5 Touchdown zone lighting system

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11.1 Physical limitation surfaces

11.2 ILS limitation surfaces

11.3 Localizer limitation surfaces

11.4 Gliding trajectory protection limitation surfaces

12 | Bibliography

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